J. Dairy Sci. 90:1751–1760
doi:10.3168/jds.2006-295

Impacts of Dystocia on Health and Survival of Dairy Calves

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ABSTRACT

The objectives of this study were to determine incidence of stillbirths and heifer-calf morbidity and mortality, and their association with dystocia on 3 Colorado dairies. A total of 7,380 calvings produced 7,788 calves on 3 Colorado dairy operations between October 1, 2001, and November 5, 2002. Dystocia score and calf status (alive vs. dead) were recorded at calving. Calves that were born alive, but died before 24 h of age, also were recorded as stillborn. Heifer calves were monitored for 120 d to evaluate morbidity and mortality. More than half (51.2%) of calves born to primiparous dams, compared with 29.4% of calves born to multiparous dams, required assistance during calving. A larger percentage of bull calves (40.0%) required assistance compared with heifer calves (33.0%). Proportion of stillborn calves was 8.2% overall, with bull calves, twin calves, calves born to primiparous dams, and those born to dams having dystocia having a larger stillbirth percentage compared with heifer calves, singletons, calves born to multiparous dams, and unassisted calvings, respectively. Multiple logistic regression models were constructed to evaluate stillbirths and heifer health while accounting for the clustering of calves within dairy. The models included dystocia score, parity, and season of calving as explanatory variables for heifer events and also calf gender, and single or twin birth for the stillbirth models. Heifer calves born to dams having severe dystocia had greater odds of stillbirth [odds ratio (OR) = 20.7] and treatment of respiratory disease (OR = 1.7), digestive disease (OR = 1.3), and overall heifer mortality (OR = 6.7). Calf gender and dam parity interacted with calving ease to affect stillbirths. For calves having severe dystocia, heifer calves and calves born to multiparous dams were at increased risk of stillbirth compared with bull calves and calves born to primiparous dams, respectively. Survival analysis demonstrated that severe dystocia was associated with stillbirths and deaths up to 30 d of age. Relatively simple interventions have the potential to significantly reduce the impact of dystocia on calf mortality and morbidity on dairy farms. Education of farm management and personnel in strategies to reduce dystocia and its effect on calf health should be a priority according to the results of this study.

Key words: dairy calf, dystocia, morbidity, stillbirth

INTRODUCTION

Dystocia is defined as delayed or difficult parturition. Meyer et al. (2001) evaluated 666,341 dairy calving records from Mid States Dairy Record Processing Center and reported dystocia rates for primiparous and multiparous dams over a 12-yr period. The dystocia scale used was from 1 to 3, where 1 = no assistance, 2 = slight problem, and 3+ = needed assistance. They estimated a primiparous and multiparous dystocia rate (score >1) of 28.6 and 10.7%, respectively. In contrast, the National Animal Health Monitoring Systems (**NAHMS**) Dairy 2002 study of dairy producers, based on their records and recollection, reported that only 3.7% of dairy cows had other reproductive problems, including dystocia and metritis (USDA, 2002).

The physiological effects of dystocia are well known. Prolonged hypoxia and significant acidosis are common problems in calves that experience prolonged or severe dystocia, which can be immediately fatal (stillborn), or reduce long-term survival (Breazile et al., 1988; House, 2002). Calves that experience prolonged hypoxia and survive are often weak and slow to stand and suckle (Odde, 1988). These impairments negatively affect absorption of colostral immunoglobulins (Besser et al., 1990) but also impair temperature regulation (Carstens, 1994). In addition, dystocia is a potential source of trauma affecting the function of the cardiopulmonary system (Roberts, 1986; Schuijt, 1990), especially when excessive force is applied during the delivery process. Thus, the potential for dystocia to negatively affect calf survival may occur via multiple mechanisms.

Meyer et al. (2000) used the definition of stillbirth defined by Philipsson et al. (1979) as death of a calf just before, during, or within the first 48 h after parturition.

Received May 16, 2006.
Accepted December 7, 2006.
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Meyer et al. (2000) reported that 7.1% of dairy calves were stillborn, based on 666,341 calvings during a 12-yr period. Primiparous dams produced stillborn calves more often (11.0%) than multiparous dams (5.7%) in their study. It also was reported that 50% of stillbirths were a direct result of dystocia, although dystocia only occurred in 10 to 30% of calvings. The remaining 50% of stillbirths resulted from unassisted births. In another study by Meyer et al. (2001), it was reported that a slight calving problem increased the odds of stillbirth by 2.91 in heifers and 4.67 in multiparous cows. For more difficult calvings, heifers were 6.76 times more likely to have a stillborn calf, whereas multiparous cows were 11.36 times more likely to have a stillborn calf. It also was demonstrated that calf gender had an impact on stillbirth rates; bull calves born to heifers were more likely to be stillborn than heifer calves.

Producers reported that 8.7% of dairy heifer calves that were born alive died before weaning (average age at weaning was 8.4 wk; USDA, 2002). The study did not collect information concerning stillbirths, nor did it report relationships between dystocia occurrence and subsequent calf survival and health. Wells et al. (1996) reported that severity of dystocia had a direct effect on dairy heifer calf survivability. They also reported that a dystocia requiring forced extraction, compared with an unassisted calving, was 4.22 times more likely to result in heifer-calf death within the first 21 d of life.

On the basis of reported incidence rates of dystocia in dairy cattle, and the expected negative impact on calf health, dystocia should be an area of great concern in the dairy industry. The objectives of this study were to determine the incidence of stillbirth and heifer-calf morbidity and mortality, and their association with dystocia on 3 Colorado dairies.

MATERIALS AND METHODS

Sample Population

Calves were born on 3 Front Range Colorado dairies with herd sizes between 1,000 and 5,000 cows. The vast majority (>95%) of cows included in the study were Holstein. Dystocia score was based on the amount of assistance that was provided during parturition. Dystocia score = 1 was assigned to births requiring no assistance. A score of 2 was assigned to the calving event that required intervention by one person without the use of mechanical assistance (mild dystocia). A score of 3 was assigned to any calving event that required the assistance of 2 or more people. Dystocia score 4 was assigned when mechanical extraction was used, and surgical procedures were assigned a dystocia score of 5. After evaluation of the data, dystocia scores 4 and 5 were combined with dystocia score 3 (severe dystocia).

Dairy Characteristics

Artificial insemination and natural mating were used in all herds. Parturition occurred in multiple-cow calving lots on the 3 dairies. Dairies B and C provided covered free-stall housing for milking cows, whereas Dairy A had uncovered free stalls. All cows were fed a TMR during the study period. Calves were routinely fed 3.79 L of fresh-cow colostrum within 12 h of birth and received pasteurized waste milk until weaning. Before weaning, all calves were housed in individual hutches. After weaning, calves were housed in group housing with 10 to 15 calves per pen.

Records

Farm personnel recorded each calving event on a form prepared by the investigators. Information recorded included date of calving, dam parity, dystocia score, calf gender, birth status of the calf (alive vs. dead), birth number (single vs. twin), and calf identification. Date of calving was subsequently used to assign a season of calving. Seasons were categorized as winter (December through February), spring (March through May), summer (June through August), and autumn (September through November). For the analysis, parity was categorized as primiparous and multiparous. Calves born dead or that died within 24 h of birth were recorded as stillborn. Heifer mortalities (nonstillborn deaths) were assigned to those heifer calves that were not classified as stillborn, but died before 120 d of age. Overall deaths included heifer mortalities and stillborn heifer calves. Bull calves and twin calves were commonly sold and lost to follow-up.

Health events between birth and 120 d of age were diagnosed and recorded by trained farm personnel, herd veterinarian, or both, for singleton heifer calves that were born alive. All heifer health events were entered into on-farm computer recordkeeping systems.

Statistical Analyses

Proportion of calvings within each dystocia score was calculated for each level of parity, calf gender, and stillbirth, and statistical significance was determined using the χ^2 test in SAS (FREQ procedure, SAS Inst. Inc., Cary, NC). The Cochran-Mantel-Haenszel option in SAS was used to obtain a P-value adjusted for differences among dairies. Logistic regression models were developed to estimate odds ratios and 95% confidence intervals. Dystocia score, parity, and season of calving were included as covariates in each model to adjust simultaneously for the potential effects of these variables while evaluating the variables of interest. In addition, for the stillbirth models, birth number was included. Calf gender was included in the overall stillbirth model. Outcome events in the models were stillborn, morbidity (respiratory, digestive, fever, miscellaneous illness, or other record of calf treatment), respiratory, digestive, heifer mortalities (1 to 120 d of age), and overall heifer deaths (stillborn and death). Dairy was included in the repeated statement in GENMOD in SAS to adjust for the nonindependence (clustering) of calvings within a farm via the use of generalized estimating equations using a marginal model. The generalized estimating equations models adjust for clustered data and provide robust standard errors. The ESTIMATE statement was used to obtain population-averaged odds ratios and 95% confidence intervals (Hardin and Hilbe, 2003). In addition, all 2-way interactions were evaluated.

To evaluate the time in days to death events for heifer calves, Kaplan-Meier survival graphs were constructed using the LIFETEST procedure in SAS. The Peto and Wilcoxon tests were used to evaluate differences in the beginning of the survival curves, whereas the log-rank test was used to evaluate differences in the tail of the curves (Hosmer and Lemeshow, 1999). Cox proportional hazard models were constructed using the PHREG procedure in SAS to account for other potential risk factors. The STRATA statement was used to account for clustering of calves within dairy (Allison, 1995). Variables included in the initial Cox proportional hazards model included dystocia score, dam parity, and season of calving.

RESULTS

A total of 7,788 calves were recorded from 7,380 calvings occurring between October 1, 2001, and November 5, 2002. Dairy A, having the largest herd size, provided more than 75% of the calves. Health events from 1 to 120 d of age were monitored for 3,544 heifer calves.

The majority of calves were born unassisted (63.4%) and assigned a dystocia score of 1, whereas 25.8% of calves were assigned a dystocia score of 2 (Table 1). Dystocia score was (P < 0.001) associated with dairy. Compared with dairy A, dairy B had a small percentage of calvings with a dystocia score 2. Dairy C had a higher percentage of calvings with a dystocia score 2 compared with the other 2 dairies. Conversely, dairy B had a greater percentage of calvings, and dairy C had a smaller percentage of calvings for dystocia score of 1. Incidence of severe dystocia was similar among all dairies.

As expected, dystocia scores differed (P < 0.001) among parities. Approximately half of calves born to primiparous dams (48.8%) were delivered unassisted, whereas 18.9% were classified as severe dystocias. By comparison, 70.6% of calves born to multiparous dams were delivered unassisted, and only 6.9% were classified as severe dystocias.

Of the 7,788 calves born, 11.1% were twins. Twin calves were more (P < 0.001) likely to require assistance during calving. More than half (56.7%) of twin deliveries required assistance during birth compared with only 34.1% of singleton births. No triplet births were recorded during the study period.

Gender of the calf also was associated with dystocia scores, as bull calves were more (P < 0.001) likely to require assistance at birth than heifer calves. Sixty-seven percent of heifer calves were delivered without assistance compared with 60.0% of bull calves. A larger proportion of bull calves had mild or severe dystocia than heifer calves.

Stillborn incidence for all calves was 8.2%. Incidence of stillbirths increased (P < 0.001) with increasing dystocia score. Parity was associated (P < 0.001) with stillbirth rate. Heifer and bull calves born to primiparous dams had stillbirth percentages of 9.9 and 15.2%, respectively, with an overall stillbirth rate of 12.6%. Calves born to multiparous dams were less (P < 0.001) likely to be stillborn (6.1% overall), with 4.5% of heifer calves and 7.5% of bull calves being stillborn. Heifer calves were less (P < 0.001) likely to be stillborn than bull calves. Overall stillbirth incidence for heifer calves was 6.3% compared with 10.0% for bull calves.

For each level of model variables, the total number and percentage of calves are presented in Table 2. The odds of being stillborn increased (P < 0.001) with increasing dystocia score (Table 3). Overall, calves born with dystocia scores 2 and 3 were 2.3 and 15.4 times, respectively, more (P < 0.001) likely to be stillborn than calves that were born unassisted. Primiparous dams were 1.7 times more (P < 0.001) likely to give birth to stillborn calves than multiparous dams. Bull calves were 1.4 times more (P < 0.001) likely to be stillborn than heifer calves. Calves that were born during winter were at decreased odds (P = 0.006) of being stillborn (OR = 0.7) than those calves born during autumn. Heifer calves having dystocia scores of 2 or 3 were 2.0 and 20.7 times more (P < 0.001) likely, respectively, to be stillborn than heifer calves born with no assistance. Heifer calves born to primiparous dams were 2.0 times more (P < 0.001) likely to be stillborn than heifer calves from multiparous dams. Although not included in the final stillbirth models, a significant interaction was detected between dystocia score and both calf gender and dam parity. For calves having a severe dystocia, heifer calves (OR = 20.7) were at increased odds of stillbirth compared with bull calves (OR = 12.9). Calves born to multiparous dams and exposed to severe dystocia were more (P < 0.001) likely (OR = 35.9) to be stillborn than

Table 1. Number (and percentage) of calves by dairy, dam parity, birth season, calf gender, birth number, and birth status

Variable	Level	Dystocia score number (%) Unassisted = 1	Mild dystocia = 2	Severe dystocia = 3	Total
Dairy					
A	Single birth	3,388 (66.3)	1,200 (23.5)	522 (10.2)	5,110 (87.2)
	Twin birth	322 (43.0)	331 (44.1)	97 (12.9)	750 (12.8)
B	Single birth	745 (70.8)	178 (16.9)	129 (12.3)	1,052 (93.3)
	Twin birth	34 (45.3)	33 (44.0)	8 (10.7)	75 (6.7)
C	Single birth	429 (56.5)	244 (32.1)	87 (11.4)	760 (94.9)
	Twin birth	19 (46.3)	20 (48.8)	2 (4.9)	41 (5.1)
	Total	4,937 (63.4)	2,006 (25.8)	845 (10.8)	7,788 (100.0)
Dam parity					
	Primiparous	1,257 (48.8)	831 (32.3)	486 (18.9)	2,574 (33.1)
	Multiparous	3,860 (70.6)	1,175 (22.5)	359 (6.9)	5,214 (66.9)
Birth season					
	Winter	922 (52.2)	585 (33.1)	259 (14.7)	1,766 (22.7)
	Spring	878 (60.3)	354 (24.3)	224 (15.4)	1,456 (18.7)
	Summer	1,325 (63.2)	592 (28.3)	178 (8.5)	2,095 (26.9)
	Autumn	1,812 (73.3)	475 (19.2)	184 (7.5)	2,471 (31.7)
Calf gender					
	Male	2,405 (60.0)	1,066 (26.6)	536 (13.4)	4,007 (51.5)
	Female	2,532 (67.0)	940 (24.8)	309 (8.2)	3,781 (48.5)
Birth number					
	Single	4,562 (65.9)	1,622 (23.4)	738 (10.7)	6,922 (88.9)
	Twin	375 (43.3)	384 (44.3)	107 (12.4)	866 (11.1)
Birth status					
	Alive	4,780 (66.9)	1,837 (25.7)	531 (7.4)	7,148 (91.8)
	Stillborn	157 (24.5)	169 (26.4)	314 (49.1)	640 (8.2)

calves born to primiparous dams that were exposed to severe dystocia (13.0). Heifer calves that were twins were 3.7 times ($P < 0.001$) as likely to be stillborn as singleton calves.

The odds of a heifer calf having any morbidity event were significantly increased for dystocia score 2 and 3 (OR = 1.5 and 1.5, respectively). Heifer calves born to primiparous dams were at decreased odds (OR = 0.8) of having a morbidity event compared with those calves born to multiparous dams. Season of birth was significantly associated with overall morbidity: heifer calves born in the winter and spring were at increased risk for morbidity compared with heifer calves born during autumn, and those born during summer were at decreased risk compared with heifer calves born during autumn.

Table 2. Number and percentage of dairy calves by dystocia score, dam parity, birth season, birth number, and calf gender for each response variable

		All calves		Heifer calves						
Variable	Level	Total	% Stillbirths	Total	% Stillbirths	% Overall morbidity	% Respiratory	% Digestive	% Heifer mortality, ≤120 d of age	% Overall heifer mortality
Total		7,788	8.2	3,781	6.3	27.5	21.5	13.7	7.9	13.0
Dystocia score	Unassisted = 1	4,937	3.2	2,532	2.4	24.5	18.6	11.7	7.5	9.5
	Mild dystocia = 2	2,006	8.4	940	6.3	33.5	27.1	18.3	7.7	12.7
	Severe dystocia = 3	845	37.2	309	37.9	41.0	35.4	19.1	13.5	44.6
Dam parity	Primiparous	2,574	12.6	1,266	9.9	27.7	22.1	13.6	8.1	16.8
	Multiparous	5,214	6.1	2,512	4.5	27.4	21.2	13.7	7.8	11.0
Birth season	Winter	1,766	7.8	839	6.4	58.8	46.6	30.6	13.3	18.3
	Spring	1,456	10.2	703	7.8	32.1	27.9	14.8	11.0	17.7
	Summer	2,095	8.3	1,002	6.6	2.6	2.0	0.9	0.7	5.9
	Autumn	2,471	7.4	1,237	5.1	23.0	16.2	11.4	8.0	12.2
Birth number	Single	6,922	7.3	3,377	5.4					
	Twin	866	15.6	404	14.1					
Calf gender	Male	4,007	10.0							
	Female	3,781	6.3							

Table 3. Summary of multiple logistic regression analysis of stillbirths, morbidity and mortality in dairy calves[1]

Variable	Stillbirth (all calves)	Stillbirth (heifers)	Overall morbidity	Respiratory	Digestive	Heifer mortality, ≤120 d of age	Overall heifer mortality
Intercept	−2.7721	−2.7086	−1.2255	−1.6791	−2.0825	−2.4346	−2.24
Dystocia score	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
Unassisted = 1	Referent						
Mild dystocia = 2	2.3 (1.6 to 3.3)*	2.0 (1.6 to 2.5)*	1.5 (1.3 to 1.6)*	1.5 (1.4 to 1.7)*	1.6 (1.3 to 1.9)*	1.0 (1.0 to 1.1)	1.3 (1.2 to 1.4)*
Severe dystocia = 3	15.4 (8.5 to 27.8)*	20.7 (13.3 to 32.2)*	1.5 (1.5 to 1.6)*	1.7 (1.6 to 1.9)*	1.3 (1.1 to 1.5)*	1.5 (1.4 to 1.7)*	6.7 (4.9 to 9.2)*
Dam parity	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P = 0.167$	$P = 0.375$	$P < 0.001$
Primiparous	1.7 (1.6 to 1.9)*	2.0 (1.6 to 2.5)*	0.8 (0.7 to 0.9)*	0.8 (0.8 to 0.8)*	0.8 (0.6 to 1.1)	0.9 (0.8 to 1.1)	1.2 (1.1 to 1.2)*
Multiparous	Referent						
Birth season	$P < 0.001$	$P = 0.400$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
Winter	0.7 (0.5 to 0.9)*	0.8 (0.6 to 1.1)	4.5 (2.5 to 8.2)*	4.2 (3.2 to 5.5)*	3.2 (1.9 to 5.2)*	1.7 (1.4 to 2.2)*	1.3 (1.1 to 1.5)*
Spring	0.9 (0.7 to 1.2)	0.9 (0.7 to 1.0)	1.5 (1.3 to 1.8)*	1.9 (1.5 to 2.4)*	1.3 (1.0 to 1.6)*	1.4 (1.2 to 1.6)*	1.2 (1.1 to 1.3)*
Summer	0.9 (0.7 to 1.3)	1.1 (0.9 to 1.3)	0.1 (0.0 to 0.7)*	0.1 (0.0 to 0.9)*	0.1 (0.0 to 0.7)*	0.1 (0.0 to 0.3)*	0.4 (0.3 to 0.7)*
Autumn	Referent						
Birth number	$P < 0.001$	$P < 0.001$					
Single	Referent						
Twin	2.7 (1.9 to 3.7)*	3.7 (2.0 to 6.7)*					
Calf gender	$P < 0.001$						
Male	1.4 (1.3 to 1.4)*						
Female	Referent						

[1]Summary includes P-value for each model term along with odds ratios and 95% confidence intervals.

*Different ($P < 0.05$) from referent category.

The odds of a heifer calf having a respiratory event were significantly increased for dystocia score 2 and 3 (OR = 1.5 and 1.7, respectively). Heifer calves born to primiparous dams were at slightly decreased odds (OR = 0.8) of a respiratory event compared with heifer calves born to multiparous dams. Heifer calves born in the winter and spring were 4.2 and 1.9 times, respectively, more likely to experience a respiratory event compared with those born in the autumn, whereas heifer calves born in the summer were at decreased odds of a respiratory event compared with calves born during autumn.

The odds of heifer calves having a digestive event were increased for those calves born to dams that had a mild or severe dystocia. No parity effect was observed for digestive events. The seasonal trend continued, with heifer calves born in the winter and spring being at increased odds of a digestive event, whereas those born in the summer were at decreased odds compared with those born during autumn.

Heifer mortalities included heifer calves that were alive at 24 h after calving, but died before 120 d of age. Only calves born to cows having a severe dystocia had an increased ($P < 0.001$) risk of death after 24 h of age than calves born unassisted (OR = 1.5). A significant parity effect on calf death was not observed. There were significant seasonal effects with heifer calves born during winter and spring more ($P < 0.001$) likely to die between 1 and 120 d of age (OR = 1.7 and 1.4, respectively), whereas calves born during summer were at decreased ($P < 0.001$) odds (OR = 0.1) of dying between 1 and 120 d of age than heifer calves born during autumn.

Overall heifer mortality increased ($P < 0.001$) with increasing dystocia score. Heifer calves with scores 2 and 3 were 1.3 and 6.7 times, respectively, more ($P <$ 0.001) likely to be born dead or die between birth and 120 d of age than heifer calves that received no assistance during birth. Parity of the dam had a significant effect on overall heifer-calf death before 120 d of age because calves born to primiparous dams had 1.2 times greater ($P < 0.001$) odds of dying than those born to multiparous dams. Heifer calves born during winter and spring had 1.3 and 1.2 greater ($P < 0.001$) odds, respectively, of dying before 120 d of age than those

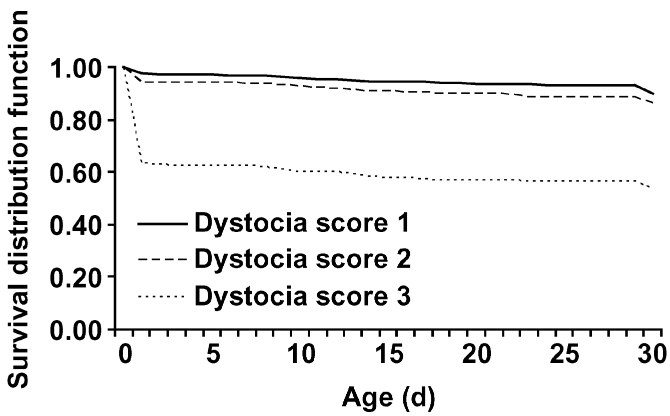

Figure 1. Survival function plot, including stillbirths, by dystocia score for 3,781 heifer calves born on 3 Colorado dairies.

born during autumn. Calves born during summer were at decreased ($P < 0.001$) odds of dying than those born during autumn. Although only 8.2% of heifer calves had severe dystocia, they accounted for 29.9% of all heifer mortalities to 120 d of age.

Survival curves, through 30 d of age, for each of the dystocia scores were compared (Figure 1). Decreased survival probability for calves having severe dystocia is dramatic and easily visualized. The Wilcoxon, Peto, and log-rank P-values were <0.001, suggesting that the survival curves differed at the beginning (primarily due to stillbirths) and also toward the end of the 30-d period. Calves having mild dystocia also were less ($P < 0.003$) likely to survive to 30 d than calves born unassisted. Survival curves, through 30 d of age, after removing stillborn calves are shown in Figure 2. The P-values for each of the 3 tests were <0.01, suggesting that severe dystocia affects calf survival beyond the first 24 h of life.

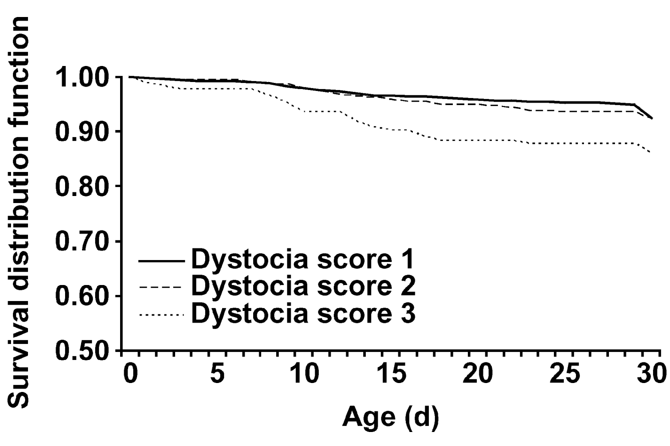

Figure 2. Survival function plot, without stillbirths, by dystocia score for 3,346 heifer calves born on 3 Colorado dairies.

Table 4. Hazard ratios and 95% confidence intervals from Cox proportional hazards model for dairy heifer mortality to 30 d of age

Variable	Hazard ratio	95% Confidence interval	Chi-square P-value
Severe dystocia	5.4	4.3 to 6.8	<0.001
Mild dystocia	1.3	1.0 to 1.7	0.018
Unassisted	1.0	—	—
Primiparous	1.2	1.0 to 1.4	0.070
Multiparous	1.0	—	—
Winter	1.3	1.1 to 1.7	0.016
Spring	1.3	1.0 to 1.6	0.063
Summer	0.5	0.4 to 0.7	<0.001
Autumn	1.0	—	—

An evaluation of nonstillborn calves born unassisted or having mild dystocia showed no difference in survival ($P = 0.75$).

The final Cox proportional hazards model included dystocia scores and season of calving (Table 4). Calves exposed to severe dystocia at birth had a hazard ratio for death of 5.4 vs. calves that were not exposed to severe dystocia, compared with 1.3 for calves exposed to mild dystocia at birth. Calves born during winter had an increased ($P = 0.016$) hazard for death (1.3), whereas those born during summer had a decreased ($P < 0.001$) hazard of death (0.5).

DISCUSSION

Dystocia Occurrence

Three general causes of dystocia are fetal-maternal size mismatch, fetal malpresentation, and maternal related causes (Arthur et al., 1989). Dystocia incidence in primiparous dams is most often due to mismatched fetal-maternal size, whereas dystocia in multiparous cows is more frequently secondary to fetal malpresentation or maternal causes. In this study, we categorized the difficulty of delivery rather than the cause.

Our findings demonstrated that dystocia occurred often on the 3 study farms and adversely affected dairy calves. Over 35% of calves required assistance during birthing, accounting for 75.5% of the stillborn calves. Although only 10.8% of calves had severe dystocia, these calves accounted for 49.1% of all stillbirths. The observation that 24.5% of stillbirth calves occurred after unassisted birth may suggest that observation frequency of calving pens and application of intervention strategies during calf deliveries are inadequate. Alternatively, research indicates that stillbirths in dairy cattle are increasing and may have a genetic component (Steinbock et al., 2003; Adamec et al., 2006).

For the purposes of this study, it must be assumed that calving assistance was provided similarly to that on most US dairies (i.e., lay personnel without direct veterinary oversight at the time of assistance). Many variables that could not be measured in this study could influence the outcome of dystocia, including magnitude of traction applied, skills, and judgment of those involved and timing of intervention. Personnel at all 3 of the dairies work closely with veterinarians, but it is difficult to determine whether assistance was always provided optimally. The proportion of calvings that required assistance in the studied dairies was large, especially for primiparous dams in which more than 50% needed assistance at calving. The authors cannot infer that this proportion of dystocia on 3 dairies is representative of occurrence throughout the US dairy industry. Rather, the focus of the study was on evaluating the impact of dystocia on calf health and survival.

The profound negative impact that a dystocia delivery has on calf health and survival paired with the subsequent effect on future dairy productivity should make calving management a larger priority on dairies. Results of the NAHMS Dairy 2002 survey of producers suggested a much smaller incidence of dystocia than reported in this study or in previous reports (Berger, 1994; Meyer et al., 2000; USDA, 2002). Because the NAHMS survey relied heavily on producer-reported events in contrast to enumeration from actual records, we believe the proportions of cows having dystocia were seriously underestimated in that report. Under-reporting suggests that dairy producers undervalue the importance of dystocia in their operation and highlights the opinion of the authors of this study that dairy producers do not emphasize managing and monitoring calving, dystocia, and newborn calf survival. It seems plausible that if dystocia is not actively monitored on dairy operations, it cannot be recognized as a priority by management.

Decreasing the number of dams that require delivery assistance and improving dystocia relief methods should be goals of all dairy operations. To achieve this goal, a number of preventive steps might be implemented. Because primiparous cows were most often affected, management should ensure heifers are inseminated at the proper age and BW, and consider selecting potential sires on the basis of known calving ease. Improved personnel training regarding proper timing and methods of intervention during calving plus appropriate methods to care for compromised newborn calves would likely decrease the impact of dystocia.

Stillbirth

Although the strict definition of a stillborn is a calf that is born dead, this study used the more common terminology that includes calves that die within 24 h after birth. It could be argued that some calves die within 24 h of birth because of suboptimal care, not as a direct result of parturition. For example, calves born without complication in freezing temperatures may die as a direct result of the environment, rather than the delivery process. Because calves compromised by dystocia will be more susceptible to environmental challenges, it is the opinion of the authors that it is reasonable to attribute the majority of such deaths to dystocia. It was noteworthy that the cold environment of winter did not seem to adversely influence calf survival in this study because calves born during winter were at decreased odds of being stillborn than calves born during autumn.

Parity was significantly associated with stillbirths. A significant interaction with parity was detected for calves exposed to severe dystocia such that severe dystocia in multiparous dams was more likely to result in stillbirth than severe dystocia in primiparous dams. This may be an effect of fetal malposition as a cause of severe dystocia occurring more frequently in multiparous dams than a mismatch of fetal and maternal size. Fetal malposition can be technically challenging to resolve. These delivery difficulties may result in more stillbirths, but it is also possible that fetal death before delivery caused some of the severe dystocias. We were not able to determine, however, whether fetal death necessitated assistance, or whether the assistance was a factor in the calf being stillborn. In addition, the reason for dystocia was not routinely recorded, and we cannot determine whether fetal size or position played a role.

More than 10% of calves in this study were twins with the majority of twins born to multiparous cows. The twinning rate in the US dairy population is increasing and is thought to be associated with increased energy in the diets or increased steroid hormone metabolism that ultimately leads to increased double ovulations (Kinsel et al., 1998; Wiltbank et al., 2000). Twin births have been associated with increased dystocia (primarily due to malpresentation) and decreased neonatal survival (Gregory et al., 1996; Echternkamp and Gregory, 1999). Because twin calves are more likely to be born to multiparous cows, fetal repositioning along with traction to deliver the calf is likely responsible for the increased stillbirth incidence.

Calves born during winter were at decreased odds of stillbirth than calves born during autumn, which is similar to what was reported by Meyer et al. (2001), in which they found stillbirths were increased during summer compared with winter. These results are counterintuitive to what was expected because dystocia makes calves more prone to hypothermia, and it has been reported that beef calves born during winter and exposed to dystocia were at increased odds of death (Azzum et al., 1993). The discrepancy between the association of stillbirths and winter (Azzum et al., 1993) and the study (Meyer et al., 2001) evaluating dairy calves may be the result of birth distributions mainly during late winter and spring than during the entire year. Decreased occurrence of stillbirths in dairy calves during winter may be the result of increased attention by herd personnel because dairy calves receive more shelter than beef calves, or they are able to adapt fairly rapidly to an environment when they have not been compromised by a difficult delivery.

Calf gender also played a role in stillbirths in this study. The proportion of bull calves that were stillborn was twice that of heifer calves. Although calf birth weight was not obtained consistently throughout the study and therefore not included in the models, it is widely reported that bull calves, on average, weigh more than heifer calves at birth (Sieber et al., 1989; McDermott et al., 1992; Johanson and Berger, 2003). Increased calf weight can cause a mismatch of fetal-maternal size, which leads to increased chance of dystocia, especially in primiparous dams. The models constructed by Johanson and Berger (2003) showed that calf birth weight was a better predictor of calving difficulty than calf gender alone. This study was not able to differentiate calves born dead from those dying within 24 h to determine if bull calves were more commonly born dead, die shortly after birth, or both. Bull calves are frequently less valuable than heifer calves to most dairies and may not receive the same standard of care; thus, decreased attention to bull calves also may lead to increased stillbirth rates. As reported by Meyer et al. (2001), calf gender and stillbirth rate depend on parity. Their study found that bull calves, compared with heifer calves, were more likely to be stillborn when born to primiparous dams and less likely to be stillborn when born to multiparous dams. In our study, regardless of parity, bull calves were more likely to be stillborn.

Because dystocia has been shown to have detrimental effects on adaptation of calves to extrauterine life, calves exposed to dystocia required additional attention than calves delivered without assistance. The main pathophysiological effects of dystocia on calves are trauma and asphyxia. In turn, this can result in postnatal metabolic and respiratory acidosis, hypoxemia, failure of passive transfer, and hypothermia. Severe dystocia has been associated with reduced body temperature, decreased concentrations of blood cortisol, and increased blood glucose (Bellows and Lammoglia, 2000). These effects can usually be minimized through easily implemented on-farm procedures. Education of farm personnel should be targeted at minimizing dystocia impacts with appropriate delivery methods, identifying compromised calves, administering fluids and oxygen to calves with acidosis, warming chilled calves, and delivering high quality colostrum immediately after birth. Standard operating procedures on dairies should be to treat every calf that was exposed to dystocia as a compromised calf. Perhaps some of the calves that were born alive, but died within 24 h later, could have been saved by implementing these simple interventions.

Because the personnel in these dairies have training in calf management, calves are routinely given colostrum shortly after birth, provided a dry, clean environment, and receive care for adverse circumstances (e.g., breathing difficulties, extreme cold, etc.). In our study, however, 8.2% of calves were born dead or died within 24 h of delivery, which is similar to the 7.1% stillbirth rate reported by Meyer et al. (2000). A 24-h cutoff for stillbirths was selected for our study to more accurately account for deaths specifically related to the birth event rather than the definition used by Meyer et al. (2000), which included deaths to 48 h. In comparison, our reported stillbirth rate underestimates what the stillbirth rate might have been if we had applied a 48-h cutoff.

Health Events

Effects of dystocia, which may be readily apparent immediately after delivery, were also found to influence heifer-calf health until at least 30 d of age. It should be noted that dairy personnel were mainly responsible for evaluating, diagnosing, and treating heifer calves. It is also common to treat multiple calves in a group-housing situation in which only a small proportion of calves show signs of disease. When the event is recorded, every calf may be reported to have the disease, although in reality, all calves were not diseased. When reviewing computerized records for these events, it is often impossible to determine which calves were ill and treated, and which were recorded as ill but really given prophylactic treatment. Other factors that may have influenced calf health include inadequate or lack of maternal colostral antibody transfer, feeding program, and housing type.

Season of birth also affected heifer-calf health. Calves born during winter and spring were more likely to experience a health event or die between birth and 120 d of age, whereas heifer calves born during summer were at decreased odds of having one of the events. Because many calves born in the cold temperatures may experience hypothermia and subsequent stress, especially those that also were exposed to dystocia, their ability to effectively fight off pathogens may be compromised. Significant temperature fluctuations during winter and spring also may cause calves to be more susceptible to disease. Even after adjusting for difficulty of delivery, dairy, and parity of dam, seasonal effects were observed.

Deaths

Increased odds of deaths between 1 and 120 d of age, analysis of Kaplan Meier survival curves, and Cox proportional hazards modeling all indicated that calves exposed to severe dystocia may have persistent pathophysiological effects that increased calf mortality. Wells et al. (1996) reviewed mortality risk factors for calves during the first 21 d of life. They found no significantly increased odds of mortality for unassisted, easy pull, or hard pull calvings; only those calves exposed to forced extractions were at increased odds of dying within 21 d of birth. Our findings imply that improved calf care during and immediately after birth may not only decrease the percentage of stillbirths as mentioned previously but also potentially decrease the proportion of calves that die between 1 and 120 d of age. Seasonal effects on calf deaths occurred, but these may be more attributable to increased calf disease during winter and spring rather than the result of dystocia.

Overall Calf Deaths

Overall proportions of calf deaths attributable to dystocia for dairies in this study was larger than what is described in studies of the dairy industry that rely on producers recollection or records. The NAHMS Dairy 2002 study (USDA, 2002) reported that overall heifer calf mortality on US dairies was 8.7% for preweaned heifers and 1.9% for weaned heifers. The reported cause of mortality was attributable overwhelmingly to infectious disease problems such as scours and respiratory disease. These percentages are comparable with the proportion of deaths reported in this study of 7.9% from 1 to 120 d of age. In the NAHMS study (USDA, 2002), dairy producers attributed only 4.1% of all calf deaths to calving problems, and stillbirth deaths were not specifically recorded. In many dairy record-keeping systems, calves are not recorded as herd members until tagged, and stillbirths are often not recorded or monitored. In our study, heifer calf deaths attributable to stillbirths were 6.3% of births that increased overall mortality of heifer calves to 13% for calves up to 120 d of age. Our results show that 8.8% of heifer calves born to dams having dystocia scores of 2 or 3 die between 1 to 120 d of age, but when combined with stillbirths, which are more closely associated with dystocia, 20.6% of heifer calves exposed to dystocia died before 120 d of age. Dystocia and subsequent health events in this study accounted for nearly 50% of all calf deaths, although we could not distinguish between stillbirths resulting from dystocia vs. fetal deaths that required assistance because the calves were already dead.

Dairy farmers tend to focus their attention on milk production and its present impact on income. Although important sources of future income, calves usually are given less priority because of time and money constraints. Heifer death losses of 13.0% (including stillbirths) by 120 d of age, however, may not be compatible with future productivity and profitability.

CONCLUSIONS

Occurrence of dystocia on the 3 Colorado dairy farms was strongly associated with increased morbidity and mortality of newborn calves, with negative impacts continuing through weaning. Education of management and farm personnel in strategies to reduce dystocia and its effect on calves should be a priority. The financial gain from reducing effects of dystocia on the 3 dairies in this study vs. the relative cost to implement these strategies should be evaluated. Relatively simple interventions using current technology have the potential to significantly reduce the impact of dystocia on dairy farms.

ACKNOWLEDGMENTS

The authors thank Veena Khunkhun, Ashley Hill, John Wenz, Page Dinsmore, Bruce Wagner, and Thomas Keefe for technical assistance. This study was supported in part by funds from the Colorado Agricultural Experiment Station and contributions to the Integrated Livestock Management Program from Colorado dairy producers.

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